AD-A099 835 COURSEWARE INC SAN DIEGO CALIF F/G 5/9

F-16 INSTRUCTIONAL SEQUENCING PLAN REPORT.(U)

MAR 81 A S GIBBONS F02604-79-C-8875

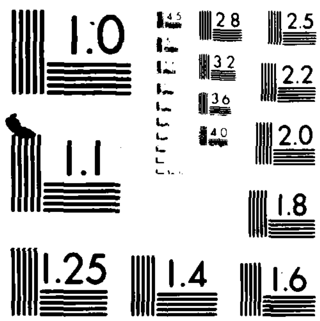
UNCLASSIFIED NL

END

DATE FILMED

6 81

DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

F-16 AIRCREW TRAINING DEVELOPMENT PROJECT

Contract No. F02604-79-C8875

F-16 INSTRUCTIONAL SEQUENCING PLAN REPORT.

DEVELOPMENT REPORT No. 23

MARCH 1981

Prepared in partial fulfillment of CDRL no. B049

by

A.S. Gibbons
Courseware, Inc.

COURSEWARE, INC.
10075 Carroll Canyon Rd.
San Diego, CA 92131
(714) 578-1700

PREFACE

This report was created for the F-16 Aircrew Training Development Project contract no. F02604-79-C8875 for the Tactical Air Command to comply with the requirements of CDRL no. B049. The project entailed the design and development of an instructional system for the F-16 RTU and instructor pilots. During the course of the project, a series of development reports was issued describing processes and products. A list of those reports follows this page. The user is referred to Report No. 34, A Users Guide to the F-16 Training Development Reports, for an overview and explanation of the series, and Report No. 35, F-16 Final Report, for an overview of the Instructional System Development Project.

F-16 AIRCREW TRAINING
DEVELOPMENT PROJECT REPORTS

Copies of these reports may be obtained by writing the Defense Technical Information Center, Cameron Station, Alexandria, Virginia 22314. All reports were reviewed and updated in March 81.

Gibbons, A.S., Rolnick, S.J., Mudrick, D. & Farrow, D.R. Program work plan (F-16 Development Report No. 1). San Diego, Calif.: Courseware, Inc., September 1977, March 1981.

Thompson, A., Bath, W., & Gibbons, A.S., Previous ISD program review (F-16 Development Report No. 2). San Diego, Calif.: Courseware, Inc., September 1977, March 1981.

Wild, M., & Farrow, D.R. Data collection and management forms report (F-16 Development Report No. 3). San Diego, Calif.: Courseware, Inc., September 1977, March 1981.

Gibbons, A.S. Review of existing F-16 task analysis (F-16 Development Report No. 4). San Diego, Calif.: Courseware, Inc., June 1977, March 1981.

Gibbons, A.S., & Rolnick, S.J. Derivation, formatting, and use of criterion-referenced objectives (CROs) and criterion-referenced tests (CRTs) (F-16 Development Report No. 5). San Diego, Calif.: Courseware, Inc., September 1977, March 1981.

Rolnick, S.J., Mudrick, D., Gibbons, A.S. & Clark, J. F-16 task analysis, criterion-referenced objective, and objectives hierarchy report (F-16 Development Report No. 6). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Gibbons, A.S. Task analysis methodology report (F-16 Development Report No. 7). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Gibbons, A.S. Objectives hierarchy analysis methodology report (F-16 Development Report No. 8). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Mudrick, D., Gibbons, A.S., & Schmidt, R.F. Goal analysis report (F-16 Development Report No. 9). San Diego, Calif.: Courseware, Inc., February 1978, March 1981.

Rolnick, S.J., Mudrick, D., & Thompson, E.A. Data base update procedures report (F-16 Development Report No. 10). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Mudrick, D., & Pyrz, K.E. Data automation of task and goal analysis: Existing system review and recommendation (F-16 Development Report No. 11). San Diego, Calif.: Courseware, Inc., September 1977, March 1981.

O'Neal, A.F., & Smith, L.H. *Management System needs and design concept analysis* (F-16 Development Report No. 12). San Diego, Calif.: Courseware, Inc., December 1977, March 1981.

Gibbons, A.S., Thompson, E.A., Schmidt, R.F., & Rolnick, S.J. *F-16 pilot and instructor pilot target population study* (F-16 Development Report No. 13). San Diego, Calif.: Courseware, Inc., September 1977, March 1981.

Schmidt, R.F., Gibbons, A.S., Jacobs, R. & Faust, G.W. *Recommendations for the F-16 performance measurement system* (F-16 Development Report No. 14). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Thompson, E.A., & Gibbons, A.S. *Program/system constraints analysis report* (F-16 Development Report No. 15). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Gibbons, A.S., & Rolnick, S.J. *A study of media production and reproduction options for the F-16 project* (F-16 Development Report No. 16). San Diego, Calif.: Courseware, Inc., February 1978, March 1981.

O'Neal, A.F., & Kearsley, G.P. *Computer managed instruction for the F-16 training program* (F-16 Development Report No. 17). San Diego, Calif.: Courseware, Inc., July 1978, March 1981.

Wilcox, W.C., McNabb, W.J., & Farrow, D.R. *F-16 implementation and management plan report* (F-16 Development Report No. 18). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Sudweeks, R.R., Rolnick, S.J., & Gibbons, A.S. *Quality control plans, procedures, and rationale for the F-16 pilot training system* (F-16 Development Report No. 19). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Gibbons, A.S., Axtell, R.H., & Hughes, J.A. *F-16 media selection and utilization plan report* (F-16 Development Report No. 20). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Thompson, E.A., Kearsley, G.P., Gibbons, A.S., & King, K. *F-16 instructional system cost study report* (F-16 Development Report No. 21). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Jacobs, R.S., & Gibbons, A.S. *Recommendations for F-16 operational flight trainer (OFT) design improvements* (F-16 Development Report No. 22). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Gibbons, A.S. *F-16 instructional sequencing plan report* (F-16 Development Report No. 23). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

Farrow, D.R., & King, K. F-16 coursewares and syllabi delivery schedule (F-16 Development Report No. 24). San Diego, Calif.: Courseware, Inc., September 1979, March 1981.

Rothstein, L.J., Hibian, J.E., & Mudrick, D. F-16 instructor/course manager training requirements report (F-16 Development Report No. 25). San Diego, Calif.: Courseware, Inc., October 1978, March 1981.

O'Neal, A.F., & O'Neal, H.L. F-16 pilot media selection (F-16 Development Report No. 26). San Diego, Calif.: Courseware, Inc., March 1979, March 1981.

Gibbons, A.S. F-16 instructional system design alternatives (F-16 Development Report No. 27). San Diego, Calif.: Courseware, Inc., September 1979, March 1981.

Gibbons, A.S. F-16 instructional system basing concept (F-16 Development Report No. 28). San Diego, Calif.: Courseware, Inc., September 1979, March 1981.

O'Neal, H.L., & Rothstein, L.J. Task listings and criterion-referenced objectives for the instructor pilot F-16 training program (F-16 Development Report No. 29). San Diego, Calif.: Courseware, Inc., September 1979, March 1981.

Bergman, D.W., & Farrow, D.R. F-16 training system media report (F-16 Development Report No. 30). San Diego, Calif.: Courseware, Inc., September 1979, March 1981.

Gibbons, A.S., O'Neal, A.F., Farrow, D.R., Axtell, R.H., & Hughes, J.A. F-16 training media mix (F-16 Development Report No. 31). San Diego, Calif.: Courseware, Inc. October, 1979, March 1981.

Farrow, D.R. F-16 training media support requirements (F-16 Development Report No. 32). San Diego, Calif.: Courseware, Inc., September 1979, March 1981.

Gibbons, A.S. F-16 training media constraints and limitations (F-16 Development Report No. 33). San Diego, Calif.: Courseware, Inc., September 1979, March 1981.

Farrow, D.R., & Kearsley, G.P. A user's guide to the F-16 training development reports (F-16 Development Report No. 34). San Diego, Calif.: Courseware, Inc., January 1981, March 1981.

Farrow, D.R., & Clark, J. F-16 Final Report (F-16 Development Report No. 35). San Diego, Calif.: Courseware, Inc., January 1981, March 1981.

CONTENTS

LIST OF FIGURES AND TABLES

Page

FIGURES

TABLES

EXECUTIVE SUMMARY

This report details the rationale and procedure for sequencing (syllabus building) the pilot and instructor pilot (IP) syllabi of the F-16. Principles of instructional sequencing are presented and descriptions given of the F-16 sequencing process and syllabus revision procedures.

Development of a syllabus involves evaluation of (1) student entry level skills, (2) training and instructional goals/objectives, (3) availability of training resources, and (4) the behavior expected of graduates. The development of a syllabus is based upon a set of learning principles. Three examples are:

1. Speed of forgetting (forgetting begins almost immediately unless there is prompt testing or rapid use of new information).

2. Interference (learning of some tasks interferes with the learning of other tasks when they possess similar but confusing differences. Remembering that final approach speeds of 155, 140, and 150 kts are characteristic of the F-4, F-16, and A-7 respectively is more difficult than remembering final approach speeds of 155 and 60 for the F-4 and piper cub respectively).

3. Transfer (prior learning of some skills enhances the learning of another skill. Skill at proper scanning of instruments for IFR flight gained in one aircraft will facilitate the same task in another aircraft).

The syllabus structure must be linked to the criterion-referenced objectives as well as the career performance goals of the students. To generate a syllabus a model must exist which describes the necessary steps to acquire a skill. For the F-16 this involves:

1. Academic training: Base preparation for task execution (workbooks, tape/slides, videotapes, lectures, discussion groups, and tutorials).

2. Practice in limited simulated performance environment: Simulators, mockups, CPT, dead aircraft.

3. Practice in real world performance environment or near real world environment. OFT, WST, actual aircraft.

Specific procedures for generating the F-16 syllabus involve:

1. Definition of the mastery models and terminal performance tests.

2. Determination of the desired levels of performance for each task (given by the CRTs).

3. Determination of the syllabus structure based upon aircraft as the only training device.

4. Determination of non-aircraft training devices to preserve aircraft utilization.

F-16 INSTRUCTIONAL SEQUENCING PLAN REPORT

1.0 INTRODUCTION

This report contains the rationale and procedure for syllabus building, also called sequencing, for pilot and instructor pilot syllabi for F-16. It attempts to present information relevant to a varied audience, and in doing so covers an overview of the principles of instructional sequencing to give a discussion context, a description of the F-16 sequencing process, and a description of syllabus revision procedures. It is hoped that those responsible for managing the F-16 instructional system, those who operate it, and those who maintain it will find information appropriate to their needs in this report.

1.1 Organization

Section 2.0 of this report presents an overview of sequencing, its relationship to other instructional development processes, and the principles it attempts to incorporate into training syllabi. Desirable characteristics of syllabi are also dicussed.

Section 3.0 describes the relation of syllabus building to the instructional technology principle of criterion-referenced instruction and testing.

Section 4.0 presents a model of skill development which serves as the basic building block of the F-16 syllabus. This discussion also describes the full context of instruction, beginning with first academic exposure to instructional material and concluding with mastery of a skill executed in job-like environments.

Section 5.0 describes syllabus building and emphasizes it as a generative process based mainly on training requirements and limited by resource availability factors. In this section a discussion of syllabus maintenance highlights the importance of continual maintenance of the syllabus and change using systematic procedures.

Section 6.0 contains a step-by-step description of the F-16 sequencing procedure.

2.0 OVERVIEW OF SEQUENCING

A syllabus designates the instructional events, both academic and training device-related, to be contained in a course of instruction and the order(s) in which they may or must be encountered by students.

The syllabus-building process is one of maximizing instructional and performance outcomes of a course of instruction. It should be performed as a generative process in which the raw materials produced during job and hierarchical analysis are transformed into an instructional sequence. Its primary aim is to define a sequence of instructional events which promotes a smooth, stepwise building of skills, from simple basic to more complex and lengthy skills, for a given population of students.

The syllabus-building process is also one of minimizing the requirement for expenditure of training resources and time. The media selection plan report (project report no. 20, "F-16 Media Selection and Utilization Plan Report") describes media selection as one of the development processes most influential on the total cost of aircrew training. Syllabus building must share that title because it determines the level and type of use that instructional media devices receive, including expensive simulators and aircraft. The syllabus also determines to some extent the amount of maintance and support effort which will be required to conduct training, since it designates aircraft configurations needed to carry out particular training missions. Fiinally, it designates the level of use of instructional personnel. In an activity as costly as aircrew training and particularly for one carried on the scale of F-16 training, it can be seen that small adjustments in either the syllabus or the media selections will have a profound effect on the total training expense. This increases the desirability of systematic, precise methods of syllabus generation.

Inherent in a given syllabus are certain assumptions about preparation level of incoming students, the expected output level of students graduated from the course, the training resources available, including instructors, materials, equipment, and facilities. For a given set of incoming student capabilities and graduate expectations, a particular syllabus should represent the best use of training resources. There is an interdependent relationship between these factors, and the change of one occasions a change in the others. Figure 1 illustrates this balance. As the student population changes, or if graduate expectations change, or if the resources devoted to training change, the syllabus itself must change also.

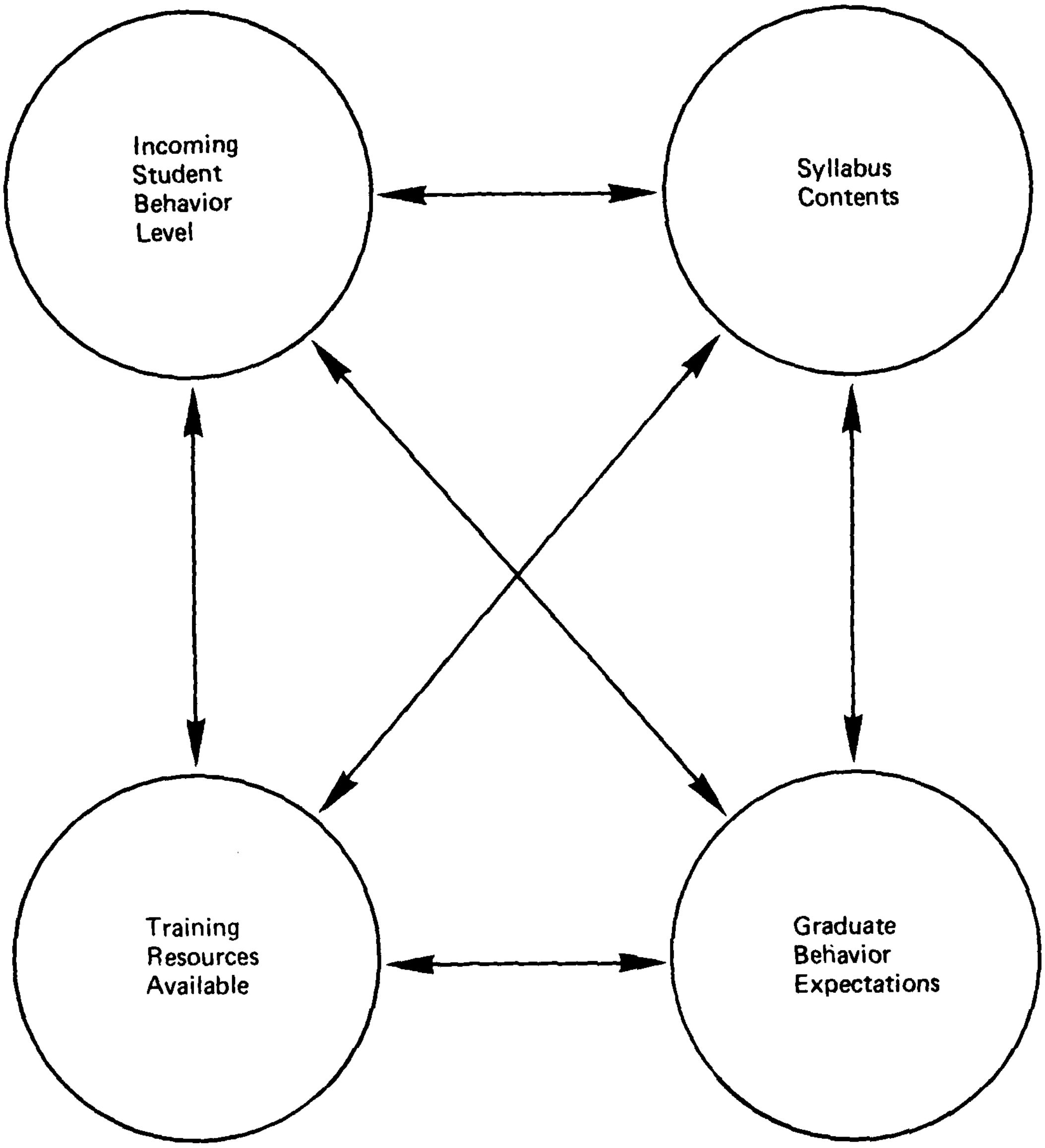


Figure 1 — Balance of Factors in Syllabus Construction

2.1 Relation of Sequencing to Other Instructional Development Processes

Sequencing has direct relationships with almost every other process in instructional development. Prior processes produce the elements and constraints for syllabus development, and subsequent processes use the information obtainable from the syllabus as an input.

For instance, sequencing has a direct relationship with task listing. Sequencing uses the elements produced during job and objectives hierarchy analysis as raw materials. Individual tasks identified during job analysis become the backbone elements of the syllabus, and individual instructional objectives form the prerequisite events leading up to them. In some cases, intermediate level instructional events not derived by the analyses are inserted during sequencing, but these are comparatively few, and the rules for adding them are systematic. From this, the importance of good job and task analyses can be seen. Since the products of analysis translate directly into syllabus events, the syllabus is limited to the extent that the analysis is inaccurate or lacks completeness or detail.

Planning for performance measurement affects the syllabus. The performance measurement plan specifies a policy concerning review and recertification through periodic performance checks. During both RTU instruction and operational assignments this program must be carried on. Reviews and recertification procedures must be built into the syllabus either in ways which take advantage of already scheduled events, or as special evaluation events. During syllabus design it is important to see to it that all required review and recertification needs expressed in the measurement plan have been met.

Target population studies influence syllabi because they define the entry-level behavior of students. Syllabi are designed to take students from that level, so it is natural that a careful identification of entry levels can assist a developer in creating a syllabus which does not contain unnecessary events.

Problem analysis and constraint analysis both constitute studies of the training environment, its practices, and its resources and have important effects upon syllabus building because they define the restrictions within which the developer must frame the syllabus or the contraints which the developer must seek to change to accommodate the syllabus.

Media selection and sequencing interact intimately with each other as concurrent processes, parcticularly in the area in training device specification. During media selection, characteristics of training devices are generated. These have a direct bearing on the syllabus which is generated and determine types of events which may be included within it. In turn, once media selections have been made, the sequence is examined carefully to

insure that the correct progression is maintained from training device to training device and that local overuse or overscheduling of one training device, particularly of training devices, does not occur in sequences the syllabus call for.

Steps following sequencing are very much affected by the syllabus produced during sequencing. During the training support requirements analysis (TSRA) process which occurs directly after sequencing, a determination of the total cost of administering the training system is made. Some of the assumptions of this process are the number and types of instructional events and levels of resource utilization called for by the syllabus.

During production of instructional materials, the order in which materials are produced is sometimes determined by the order in the syllabus, particulary when impending deadlines are evident. At any rate, the list of instructional events in the syllabus is the sole determiner of the inventory of instructional materials and support items which must be produced.

During implementation of the instructional system, a syllabus, which is cast ultimately in the form of a day-to-day schedule of student events, serves as the menu for student instructional events and the benchmark against which student progress through training is measured.

2.2 Principles Utilized in Syllabus Building

Syllabus building is an engineering process which attempts to balance the best available principles of the psychology of learning with the most efficent use of training resources and the organization of the learning sequence most likely to provide motivation for the syllabus users (both students and instructors). It is possible to conceive a syllabus carried out entirely within the aircraft cockpit, without classrooms or intermediate training device use. This type of syllabus is a not-too-distant-past reality and the tendency to use aircraft as the only training device is still a tendency in some communities. Such syllabi are highly motivating to students and instructor uses but are not efficient in resource use and most often are not sound in terms of learning principles. Likewise, syllabi designed with economic factors as the main driving force are often impoverished in their attention to the realities of learning and user motivation. Though these syllabi are lower in immediate cost, there is reason to believe that long-range performance and motivation outcomes suffer from the overemphasis on the economy.

In order to achieve this balance, prinicples from each of the three main areas--psychological principles, economic optimization principles, and user motivation principles--must be consciously applied.

Tables 1, 2, and 3 list several of the more important principles in each area and the implications they hold for the syllabus-building procedure. Various features of the sequencing procedure described in this report are intended to carry out the implications in actual practice and to insure that syllabi created do maximize the use of those beneficial principles and avoid inefficiency.

2.3 Desirable Syllabus Characteristics

Syllabi should possess certain characteristics for aircrew training purposes. Some of the most important are listed below.

2.3.1 Deliberateness, Generative Creation

Syllabi should be produced through a systematic, deliberate process, and the logic used to produce them should be available for review. That is, the trail of decisions generated during production of the syllabus should be available for inspection by those responsible for maintaining it. Syllabi produced in this fashion will be revisable as instructional content, resources, best knowledge from research concerning training sequence, and aircraft mission emphasis change. Since the syllabus is a basic instructional system document it must be kept current and will be revised periodically as conditions dictate. Being able to change it on rational and logical, rather than subjective bases, makes it more likely that the syllabus will remain an efficient one.

One implication of this position is that both the syllabus process and product will be more complex, will require more manpower to maintain, and will present heavy bookkeeping and document update requirements to the instructional system. The requirement for this, though it is a discouraging prospect to system operators, is analogous to a similar requirement placed upon materials manufacturers and airframe engineers as the materials used in aircraft were made to increasingly demanding specifications and required more and more complex processes to produce. Once the commitment was made to the added data manipulations required, it was found that it enabled more sophisticated applications in the form of faster, stronger, lighter aircraft.

Syllabi generated deliberately will be more difficult to generate and maintain but are necessary if instructional systems are to increase the precision and efficiency of effect during operation.

2.3.2 Cost Minimization

Since maximum training efficiency levels are one of the main concerns of the syllabus, minimizing costs where possible without degrading training must be one of its characteristics. The

Table 1--Psychological principles related to syllabus development.

Title	Principle	Implication for Syllabus Building
Information overload	Students are able to intake only a limited amount of new factual informatin in a given time span.	Space factual learning appropriately to avoid information overload.
Speed of forgetting	Forgetting begins to occur almost immediately unless testing or use of the information occurs to fix information in memory.	Test soon after learning of factual information. Provide opportunities for use of factual information in performance as soon as possible after learning. Drill and test periodically for review and refresher purposes.
Information integration requirement	Integration of new information into existing knowledge structures requires relating it to previously learned information.	Prescribe regular reviews and cumulative syllabus structure incorporating old and new learning into longer sequences.
Minimum motor skill integration time	Integration of motor skills into longer complexes of motor skills requires a certain minimum amount of practice to achieve smooth, consistent behaviors which will resist loss.	Generation of syllabus based on best estimated required training time rather than on the basis of resource constraints.
Interference	The learning of some tasks and information interfere with the learning of other tasks and information when confusing similarities exist between them.	Separate interfering tasks in the syllabus sequence or provide adequate emphasis and discriminative overpractice if they are to be taught.

Table 1 (cont.)

Title	Principle	Implication for Syllabus Building
Transfer	Learning of some skills faciliates the learning of certain other skills because of similarity in task sequence, similarity of component subtasks, similarity of cognitive processing demands, or similarity of knowledge required.	Put high transfer tasks in sequence such that learning of one task may be allowed to benefit learning of subsequent tasks.
Mastery of basics	Basic building blocks of higher level behaviors should be well-learned to make combining into longer chains of behavior easier, less demanding, and less wastefull of resources through student error.	Insure that basics are practiced sufficiently and avoid the temptation to move quickly to complex behaviors when early behaviors appear to be easily acquired.

Table 2--Economic/optimization principles related to syllabus development.

Title	Principle	Implication
Continous flow	The syllabus sequence must not schedule training devices in such a way that demand for a given training resource experiences peaks and valleys which create bottlenecks and cause students to wait for the use of the resource.	Spread sequence events as much as possible over a range of training devices, avoiding over dependence upon one or a small number of devices, particularly the ones in short supply or which are expensive to acquire.
Least cost	The syllabus must provide a least total cost method of training students to a given level of proficiency through the use of a mixture of high- and low-cost training resources.	Select sequences which make maximum use of lower cost training devices and bring students to higher cost devices only after adequate preparation in basic skills and knowledge.

Table 3--User motivation principles related to syllabus development.

Title	Principle	Implication
A "now" progress to be perceivable	Student and instructors should be able to perceive that progress toward long- and short-range course goals is being made during each study and performance event.	Provide early hands on practice as soon as possible with real equipment within limits of safety. Avoid long sequences of study or practice which show little apparent payoff in skills or relevant knowledge. Build syllabus study units in terms of time required to completion as much as possible.
Maximize rewards available	Allow students to earn rewarding opportunities through excellence in study and performance.	Design syllabus events to allow accelerated students to meet challenges slightly above those encountered by average students.
Avoid punishing contingencies	High achievement should not be rewarded with punishing experiences, which include the withdrawal of opportunities.	Do not eliminate opportunities for additional flying or study on the basis of early success.

problems of complexity, manpower, and bookkeeping requirements described in the previous paragraph are minimized substantially when compared to the potential they create for savings. When syllabi are written for expensive (high volume or high cost) training systems like those found in aircrew training, small changes in the syllabus can effect large savings in the cost of training. However, most of these small changes are not possible without a flexible process made possible by the additional recordkeeping and personnel already mentioned.

2.3.3 Empirically Based

During the generation of a syllabus certain assumptions are made concerning the amount of instruction and practice required by a student at a given entry level. As the syllabus is implemented it can be empirically determined from students' actual performance data how accurate those assumptions were, and as this empirical data base grows, the syllabus can be changed to adjust incorrect assumptions. Until a syllabus has been through this validation process it should be treated as a tentative document.

One requirement to make possible the empirical data feedback described here is a precise and reliable performance measurement system and the commitment on the part of the training management and instructor to observe the standards of the performance measurement system for progressing and graduating students.

2.3.4 Flexibility to Individual Student Requirements

If the generative syllabus technology presented in this paper were carried out to its ultimate extent, a syllabus tailored specifically to individual students and based on each one's own learning history could be created. Such a practice is probably not far off in the future if the techniques of syllabus generation improve. It would be desirable from a learning and performance point of view as well as an economic one. Since all students do not learn at the same pace, however, and since individual syllabi are not possible, a syllabus must be constructed for a particular level of student (the fast student, the slow student, or the average student), and a major decision must be made concerning the flexibility which will be allowed in the syllabus to accommodate students which differ from the type. If the syllabus is to accommodate the needs of slower students, additional instructional events must be available so slower students may have the necessary level of practice. Faster students progress ahead of others, and either the option of early graduation from the course or the opportunity for advanced instructional events during the course must be provided to maintain the motivation of those students and to make the best use of their unique talents. (See project report no. 14, "Recommendations for the F-16 Performance Measurement System" for an example of this.) The syllabus must be flexible enough to prescribe instructional events for all classes of students.

3.0 SYLLABUS STRUCTURE, CRITERIA, AND MASTERY MODELS

The development of a syllabus for aircrew training must be closely related to the principle of criterion-referenced instruction and testing. This section presents a discussion of the relation between syllabus structure and criterion-referencing.

3.1 Syllabus Structure for Aircrew Training

Figure 2 is a diagramatic representation of the structure of syllabus for aircrew training and for competency training in general as well. Main parts of the syllabus are: (1) terminal course evaluation, (2) intermediate evaluation points at the end of phases or sequences of training, (3) sequences of real-world or simulated real-world practice of developing behaviors, (simulator and aircraft practice), (4) an intermediate level of simulated exercises of highly fragmented performances related directly to the real-world exercises but much more limited in scope (isolated task practice in non-job environments), and (5) series of academic instruction prerequisites, providing the student with the verbal and cognitive skills prerequisite to attempting performance of tasks. Note that the academics/isolated task practice/real-world task practice sequence is cycled through repeatedly. Note also that several academic prerequisites may precede individual behavior practice and that several individual behaviors are prerequisite to job behavior practice.

All instructional events contained in the syllabus come from three sources: (1) instructual events derived directly from the job task listing, the criterion-referenced objectives, and the objectives hierarchy (the major source), (2) syllabus events created to approximate job behavior which are either too dangerous, too expensive, or too difficult for students to attempt during early stages of training, and (3) instructional events allowing the student to review and combine previously-learned behaviors or attempt them in more complex performance environments.

3.2 Criterion-referenced Syllabi

Criterion-referenced syllabi assume that the goal of a course of training is a performance level which students are expected to reach. It is an axiom of criterion-referencing that students do not graduate until they have reached the course performance goal at the expected level of precision. The course performance goal is sometimes called a "mastery model", the model of the behavior students are to master in the course. It consists of a statement of behaviors students are expected to master and the quality and precision standards associated with each. For F-16 behaviors, conditions and performence standards are expressed in criterion-referenced objectives. (See project

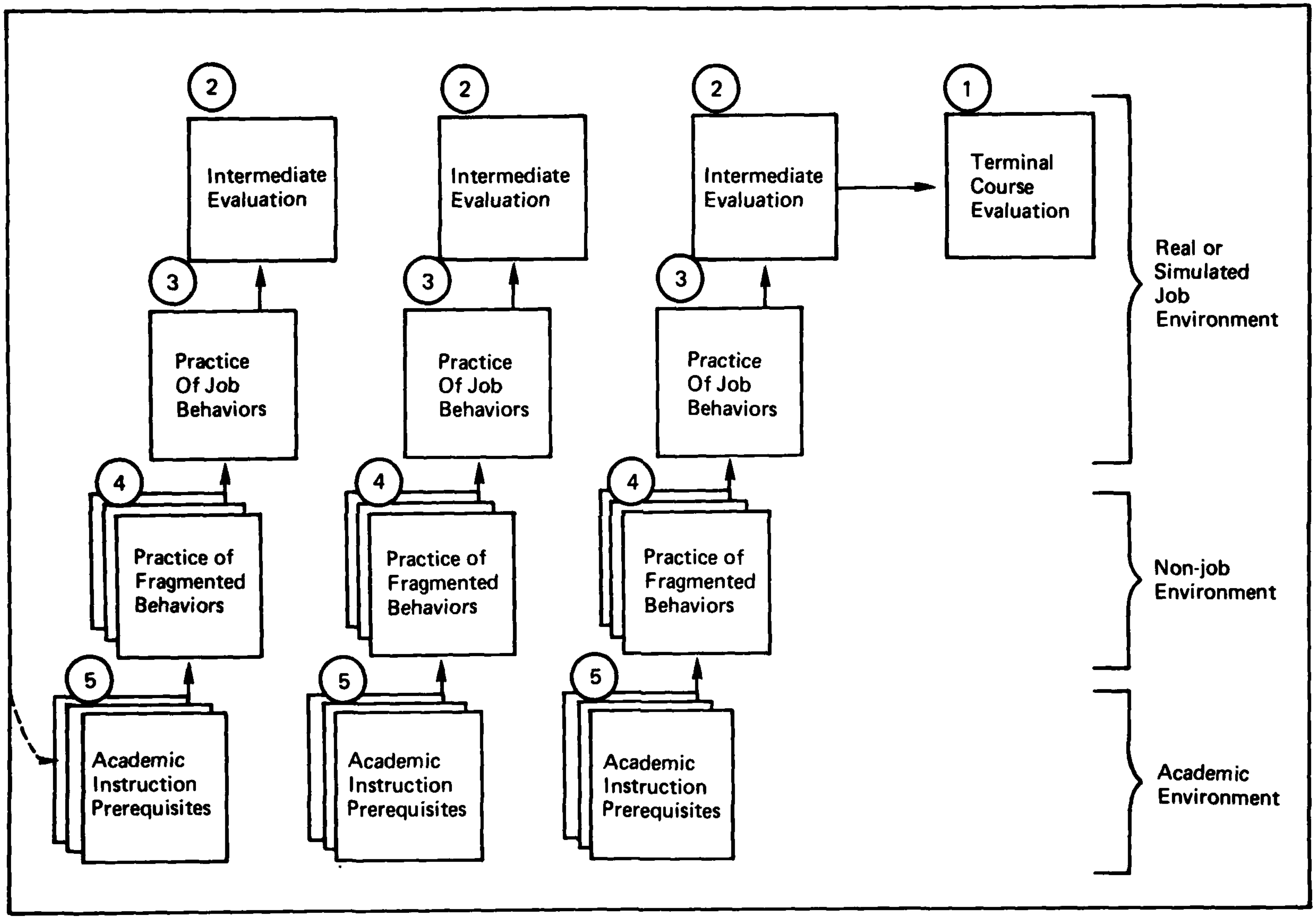


Figure 2 – Diagrammatic Representation of Syllabus Structure

report no. 5, "Derivation, Formatting, and Use of Criterion-referenced Objectives (CROs) and Criterion-referenced Tests (CRTs).") In Figure 2, the terminal course evaluation is a measurement of student attainment of the mastery model. The problems encountered in making criterion statements of this type are discussed in project report no. 14, "Recommendations for the F-16 Performance Measurement System".

Not only are terminal course mastery checkpoints required for criterion-referenced syllabi, but intermediate checkpoints as well. Figure 2 represents formal intermediate evaluation points for which aircrew trainin, might represent end-of-phase evaluations. Just as students do not graduate from a course until performance has reached criterion (mastery model) level, they should not pass by these intermediate evaluation points until they have met the applicable performance standards. Remedial instructions and retesting may be necessary for students to accomplish this, and within resource expenditure limits some students may find it impossible.

The architecture of evaluation points described does not exhaust the possible use of criterion-referencing in syllabus structure. The exit from virtually every main block of instructional experience may be used as a checkpoint of the effectiveness of foregoing instruction and the students' readiness for subsequent experiences. Consideration in naming the checkpoints actually selected must beware of overtesting yet insure that students are well-prepared to make the best use of more expensive training media involved in higher levels of task practice.

The F-16 syllabus will be a criterion-referenced syllabus. Without such a syllabus it is difficult to conduct the training of pilots within any secure knowledge of the capabilities of course graduates. The introduction of criterion-referenced structure into the F-16 syllabi makes possible not only a careful recording of student attainment of intermediate and terminal course goals, but careful recording of student progress toward those goals, a diagnosis of areas of student performance deficiency (collective and individual), and the ability to insure that training equipment and resources will be used only by students who are ready to obtain the maximum benefit from their use. In the long run this means more efficient use of training resources.

3.3 Criterion-referencing and Career Performance Goals

Only very seldom is a course of training an end in itself. A given course is very often but a single phase of a career or long-term training plan. Because the various portions of a career training progression must fit together, complement each other, and act as a correlated sequence, it is proper to look upon the syllabus for each of them as a part of a larger, continuous training course. It is desirable that this training course

have a syllabus (a composite of the individual course syllabi) which is criterion-referenced, including a course mastery model. The course mastery model in this case is a career mastery model as well, and the individual course terminal evaluation points become intermediate evaluation points to the career syllabus (using the Figure 2 terminology and structure).

For pilot training in general some manifestations of a criterion-referenced career syllabus structure are apparent in the progression of pilots from basic training through career mastery attainment. A student technically does not progress from school to school (i.e., basic EFLIT, RTU, Operational Squadron) unless he meets certain minimum performance criteria. However, whether the career syllabus constructed in this way is actually functioning as a criterion-referenced mechanism depends upon the adequacy with which course mastery models and terminal behaviors have been specified and the degree to which testing is truly criterion-referenced rather than subjective-judgment-based.

This perspective of individual course syllabi fitting within the career course syllabus to form a larger criterion-referenced syllabus structure is a very important perspective. Different stages (courses) in a pilot's training often do not require the training of all new behaviors but instead require the raising of many behaviors already acquired at a basic level of competence to a higher performance standard or to capability for performance under increasingly difficult circumstances.

The designation of levels of intermediate criterion performance within a course (as well as between courses) is desirable over designation of a single terminal performance level for motivational and administrative purposes. Motivationally it is important for the student to perceive his own progress in attaining a body of skills and becoming qualified as a pilot. In the administration of aircrew training, goals must be stated for student performance which can be achieved within a reasonable training period so that it can be determined whether student progress is satisfactory and if appropriate amounts of training resources are being spent for particular students. Moreover, between-syllabus levels of performance become important because they define to commanders the real performance capabilities of the pilots under their command, thus determining the ways in which these pilots may be used to complete missions. A student will, in the course of his flying career, reach very high levels of precision in control of an aircraft, but only a certain minimum level of control is necessary before he is ready to progress to more involved behaviors requiring control to be exercised. Control continues to be developed in this fashion as the student progresses to more sophisticated behaviors. It is important to emphasize that this is not a recommendation that the student be advanced to more complex behaviors before he has established a solid basic competence, but it is a recommendation that once minimum competence has been reached training proceed into new areas.

4.0 MODEL OF A DEVELOPING SKILL

To make possible a systematic, generative syllabus development procedure, a model has been constructed to describe the process training of a single skill. It contains: (1) optional instructional events required during training, (2) their sequence, and (3) the instructional variables which may be manipulated during that sequence. This model, which is diagrammatically presented in Figure 3 and is described in this section, is used as the basic building block of the syllabus. It makes the following assumptions:

1. Student ability to perform tasks requires instruction which can most efficiently be administered outside of training device and aircraft. Though it may be desirable to review that instruction or use media aids as adjuncts to the use of training devices, it is assumed that training device time can best be economized by having the student ready to use the device by appropriate prior instruction--not only in procedures to be executed, but in the use of the device itself.

2. A general sequence of training experiences drawing the student from more simple to more complex performance environments is optimal in terms of developing skills with least resource consumption.

3. A procedure of training individual, isolated skills to certain minimum tested levels of proficiency is in the long run more economical than moving to more complex combinations of skill too soon. Students are expected to derive the maximum benefit from training resource utilization only if they are fully ready for the instructional events they encounter.

The skill developing model is presented in Figures 3 and 4 in two parts. Figure 3 (which is a more detailed version of Figure 2) presents the full context of instructional events in skill development, and Figure 4 presents specific detail on the use of training devices within that context. As anticipated by the assumptions listed above and as shown in Figure 4, academic training forms a first phase of skill development with: (1) the statement of verbal information necessary for skill execution, (2) adequate drill and practice on difficult memorized information, (3) practice in difficult discriminations (classifications) and rule-applications, (4) individual and group solving of job-like problems, (5) tie-together where necessary of interrelated information items into a coherent background knowledge-base, and (6) non-equipment related simulated cognitive practice and rehearsal.

It is a critical feature of the model that academic training related to the performance of a particular skill be placed imme-

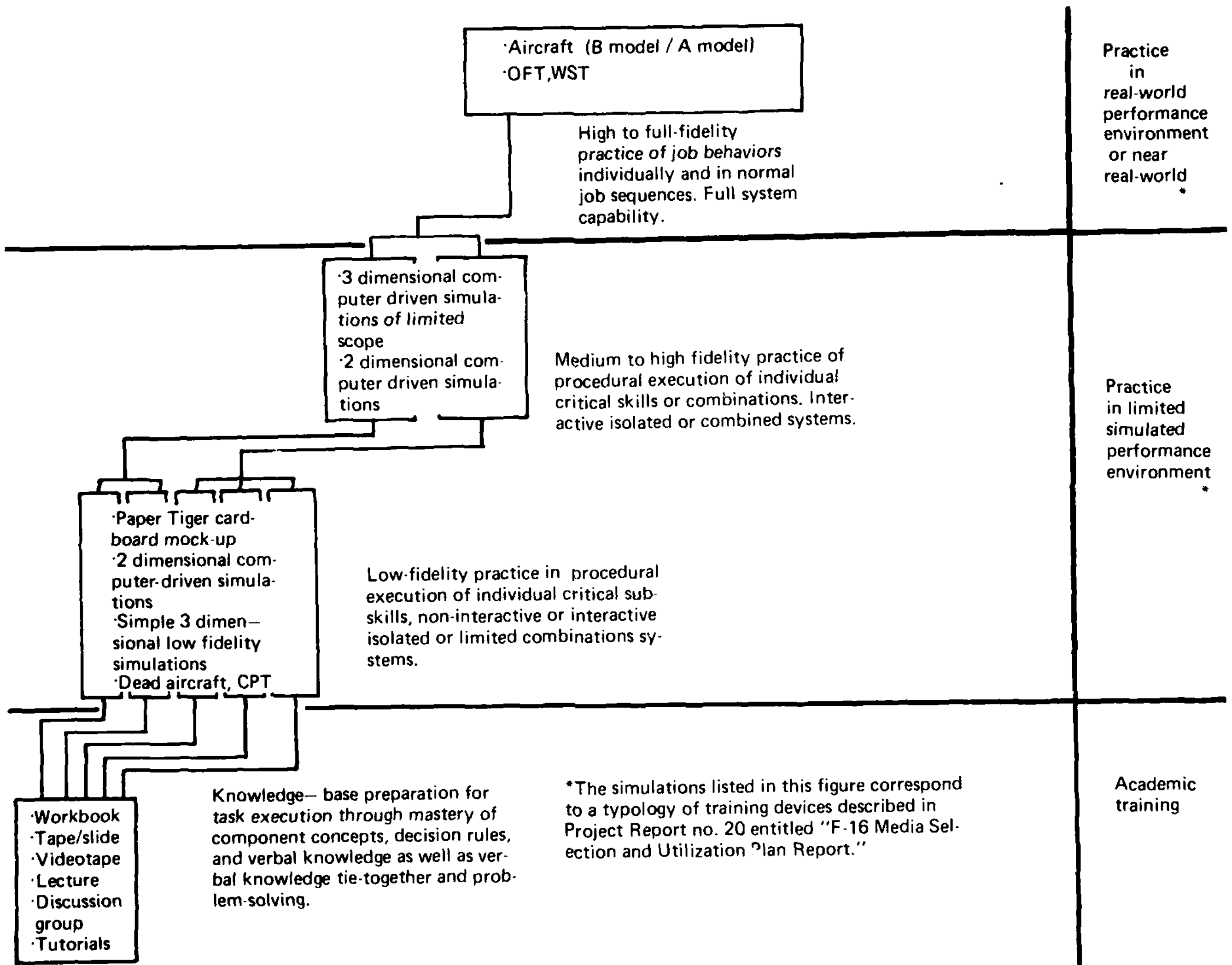


Figure 3 — A General Model of Skill Development Across Training Events and Devices

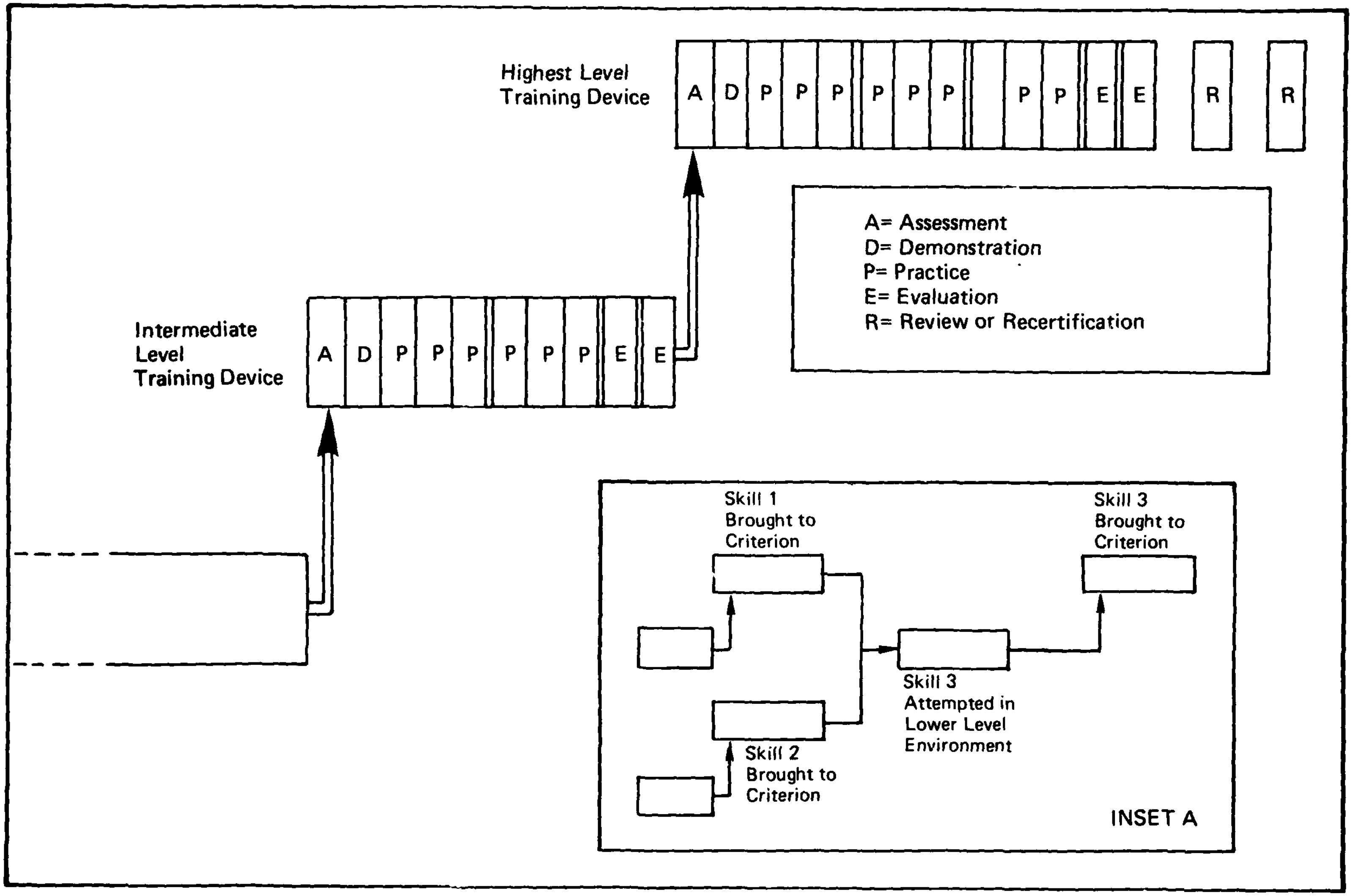


Figure 4 — Training Events in Skill Development Affecting Syllabus Dimensions

diately prior to the time when students will begin practicing the skill or its subskills. The diagram is intended to suggest that several academic training segments may relate to subskill training and that practice in several isolated subskills may be prerequisites to more advanced training. By insuring that low-level skills are well-trained in this way, it is expected that the training of higher level skills can be executed using fewer resources. This in fact is only an extension of the philosophy behind simulator use to its logical conclusion.

A second stage of skill development interwoven in sequence appropriately with the academic training is the practice of particularly difficult or critical subskills isolated from their present skills. The media selection process described in project report no. 20, "F-16 Media Selection and Utilization Plan Report," contains a series of steps (see Section 3.0 in project report no. 20) whose purpose it is to identify any of those critical, often subtle skills which may have escaped the analysts during task analysis. Often these skills, which may seem unimportant, can hinder a student's performance under high stress or precision timing conditions if they are not adequately pretrained. These skills may be practiced most often on relatively simple two and three dimensional simulation equipment with low-fidelity and interaction requirements.

The third stage in skill development is the practice parent skills and combinations of skills. These sequences represent near-job-like performance requirements in near-job-like environments. Though the total job environment need not be present during performance, the most important features relating to task performance must be. A high level of fidelity as far as task stimuli, response capabilities and requirements for timing, and blind performance must be incorporated into the training.

The final step in skill development is the exercise of the skill in real-world job environments or high-fidelity simulation of them. Practice of skills in this environment should cover the entire spectrum of operational conditions and the full range of job demands combined together into complex scenarios.

Two principles which apply to this sequenced progression through training devices are:

1. Once basic simulation levels have been passed and students have encountered more sophisticated performance environments, requirement for the student to regress to the simpler environments for further practice should be questioned unless the student is encountering difficulty in the more complex environment. It is only recommended by this report to the extent that demonstrated validity of simulator practice can be made for F-16 tasks with F-16 training devices.

2. Students may make considerable progress between practices, but caution should be exercised against moving the student off basic exercises before he begins to feel confident. Caution against too fast an advancement through the syllabus is also given. It is possible that students showing high capability levels early can be later penalized if they find their mastery of basic tasks weak.

Figure 4 describes the training events which may take place in the succession of traing devices described in Figure 3. Figure 4 shows instructional events in the learning of an individual task for one training device.

Focusing specifically on the development of a skill in the highest level training device, the aircraft in this case, the first step in skill development is a preassessment (P) of the student's ability to perform the task at the criterion level. If the student can accomplish that, there is no need to proceed with training, and the student should progress. If the student cannot perform to criterion, training in that device should proceed. (NOTE: The evaluation taking place in preassessment may be highly informal if the student and instructor are sure the student is not able to perform the task. Preassessment may take the form of a verbal exchange in such cases. If the student feels capable, however, and there are no safety risks to prevent him from attempting the task, a more formal performance measurement procedure should take place. In aircrew training syllabi, where transition of experienced pilots from one aircraft to another is being made, this preassessment of the incoming pilots' already-mastered skills can be a contributor to the efficient operation of the instructional system.

Following preassessment should come an appropriate form of demonstration (D). This may include single or multiple demonstrations, and the student may view it (them) from different perspectives--as a passenger in a craft piloted by the demonstrator, or from another craft. Moreover, demonstrations may be live or vicarious, such as on video or even audio tape. Demonstrations may vary according to: (1) level of realism, (2) the timing of the demonstration, (3) the observability by the student of relevant acts which are a part of the performance of the demonstrated skill, (4) the complexity and length of the demonstrated task, or (5) in the number of repeated demonstrations which the student is allowed to observe.

Following the demonstration it is desirable for the student to practice (P) the skill with whatever cues, prompts, and feedback necessary. During the course of practice these should be removed systematically, with the exception of feedback, which is always necessary. Dimensions relative to practice are (1) realism of the performance environment, (2) number of grouped or massed practices allowed within a closed time frame, (3) number of spaced practices (the number of different practice sessions),

(4) the elapsed time between practices, and (5) the level of cueing, prompting, and feedback which the student receives during each performance of a skill. It is assumed that informal performance measurement takes place every time the student performs the skill during practice. For administrative and student motivational purposes and progress reporting, formal measurement of the best performance during a practice session should also be made. The results of that measurement serve as a benchmark of student progress and training effectiveness.

Following practice, when it has been determined that the student is ready to challenge the criterion, formal evaluation (E) may take place. The dimensions of this evaluation include (1) the level of cueing and prompting allowed by instructors, (2) the number of attempts allowed, (3) number of spaced evaluations required for certification, and (4) the elapsed time between evaluations.

Performance assessment policies are discussed in project report no. 14, "Recommendations for the F-16 Performance Measurement System." The performance measurement system discussed there with its detailed record of student performance and the teaching made possible for specific areas of student growth, makes a system of continuous evaluation possible. Normally it would be recommended that the student be evaluated multiple times to insure that good scores were not the result of a fluke or an unusually good day and that grades recorded represent real and consistent behavior levels. The opposite reasoning applies, as multiple measurement guards the student against bad days as well. Having a performance measurement system that continually monitors student progress allows one-time formal evaluations to take place backed up by evaluations made during practice and gives the evaluator some estimate of the consistency and stability of the students' performace.

Syllabi are concerned with both the establishment and the maintenance of skills, and one of the dimensions of the syllabus must be provision for periodic practice and evaluation of skills already mastered in such a way that they may be systematically maintained. Once it has been ascertained that a student has met the measurement criteria, a periodic re-evaluation and recertification (R) must be conducted as well as periodic review practice to insure adequate maintenance of the skill. The dimensions of this review and evaluation function are much the same as for practice. They include: (1) The level of realism of the performance environment, (2) the number of massed practices, and (3) the number of spaced practices, (4) the elapsed time between the practices. Cognitive refresher training will also be necessary prior to these review events.

A note of caution should be sounded relative to refresher training and recertification. The specification of numbers of practices and elapsed time between practices should not be interpreted to mean that those are the criteria for recertifi-

cation. Flying or performing in a simulator a certain number of certain tasks does not constitute recertification in a criterion-referenced syllabus. As practices are concluded during the review, formal evaluation should take place using criteria specified at the students' advanced level of performance. It is this measurement which consitutes the recertification. It is misleading and dangerous to say that because a student has survived a certain number of instructional events, that he is qualified in those events. Criterion judging prevents that from happening.

In Section 5.0 the description of the the sequencing procedure will show that the general model of skill development is the fundamental building block of the syllabus. Using this model and giving specific values to each of the dimensions for specific tasks structures the syllabus from within, rather than imposing form and proportion on the syllabus through resource constraints or preconcieved ideas of the developer.

The dimensions assigned to this structure taken cumulatively are the dimensions of the syllabus, for the syllabus is made up of a collection of individual task training structures linked together in their prerequisite (as determined by the task listing) sequence or the sequence of best transfer from one skill to another. This is demonstrated in the inset on Figure 4 which shows first the mastery of prerequisite (or high transfer) skills 1 and 2 to a given performance criterion and then the practice of skill 3 in first simple and then complex environments.

5.0 F-16 SYLLABUS GENERATION PROCEDURES

This section contains a description of the procedures used in the generation of the F-16 Syllabus. Following the brief overview a step by step review of the procedures is presented.

5.1 Generative Syllabus Construction and Maintenance

The principles, models, and procedures described in this and the preceding sections of this report provide a practical mechanism which can be used to generate instructional syllabi. It should be apparent to the reader that generating syllabi in this fashion rather than by traditional methods produces side effects, including an increased bookkeeping load, and the requirement for subject-matter expert involvement at a detailed level of decision-making on a continued basis. A procedure which seeks to generate a syllabus in a logical way from data must expect these results.

Along with these negative side effects, the syllabus generated can also be expected to have some useful properties. One anticipated benefit is the possibility of a comparatively precise self-adjusting capability. During the construction of a syllabus using the generative procedures described in this report, best estimates are used to determine the dimensions of the demonstration, practice, evaluation, and review events for each task because no current body of data has been amassed specifying values for those variables. A well-managed evaluation and performance measurement system can produce data which indicate the adequacy of the syllabus. As these data are gathered on student and syllabus performance, it will become apparent which dimensions were mis-estimated, and corrections to the syllabus may be made. Over time this will make possible increased efficiency in the syllabus. As the backgrounds and capabilities of student groups entering training change, the syllabus can be systematically adjusted to accommodate fluctuation. This adjustment will be possible on the basis of operational data and in a way not possible with traditionally-constructed syllabi. Once this procedure is adopted and syllabi are constructed after this fashion and feedback loops are established and utilized, data will begin to accumulate concerning the speed with which given students of given characteristics can be trained to given levels of performance. This data base will be useful not only in the maintanence of existing syllabi but also in the generation of new syllabi for the F-16 and other aircraft.

The alternative is the creation of syllabi through methods which are not generative and produce syllabi which are less efficient and less responsive to data from actual use. It is important to understand that a syllabus generated by this method must be revised by this method, therefore the costs of generating

the syllabus initially do not disappear once the syllabus has been generated. Care must be taken to see that the syllabus is kept in an updated condition continually. In a cost-conscious environment this does not appear on the surface to be good news, but if instructional systems are to become more efficient in the utilization of extremely costly training resources this is a commitment which trainers must make, and there is a high likelihood that it is an activity which will more than pay for itself in the long run through savings.

5.2 Overview of Syllabus Generation Procedures

Syllabus generation as described in this report can be looked upon as a four-stage process consisting of (1) definition of mastery models and terminal performance tasks, (2) determination of specific tasks to be learned and the levels of desired performance for each, (3) determination of the syllabus structure based upon using the aircraft as the only training device, and (4) determination of possible utilization of non-aircraft training devices to relieve aircraft consumption.

5.3 Step-by-Step Sequencing Procedure Description

This section contains a step-by-step, description of the sequencing process. Figure 5 is a flow chart representation of the steps in the process. Each is discussed individually below.

5.3.1 Step 1: Define the Mastery Model for each Course Being Sequenced

The first step in the sequencing process is to determine the desired terminal behavior of students being graduated from each course which is being sequenced.

Mastery models may be defined in two ways. They may be defined as a group of particular problems which the student must challenge and successfully complete. An example would be the definition of an air-to-air mission scenario the student must fly containing a particular mission objective of controlled difficulty and a particular set of optional contingencies likely to occur during the mission. This type of mastery model is appropriate when complex and lengthy sequences of behavior are the goal of training. Such behaviors, since they approximate real-world events and are unpredictable and difficult to evaluate cannot be evaluated exhaustively and separately. The stating of a mastery model as a problem assumes the student must be ready for all contingencies. A mastery model made up of problems of this sort must be comprehensive and cover the entire range of job behaviors. One problem situation is not enough, but a problem situation for each main area of job performance, for instance for each main mission type, may be required. The mastery test

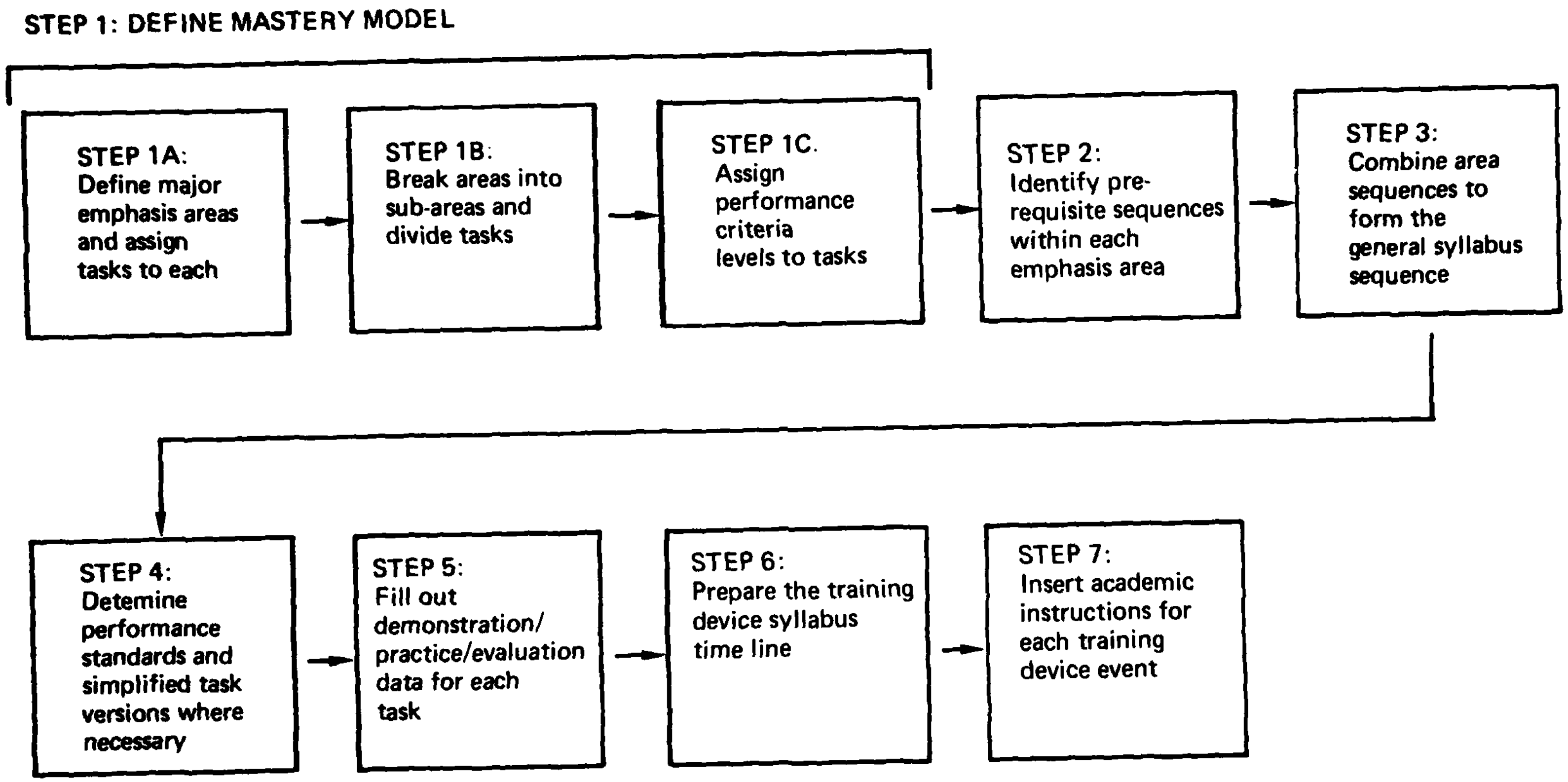


Figure 5 — Flow Diagram of the Syllabus Generating Process

resulting from such a mastery model would be a series of problem situations for the student to challenge and complete successfully to be fully certified. This method of mastery model definition is especially important for certifying more experienced and competent performers because it samples a wide range of behaviors and calls for broad skills less experienced persons often do not have. The difficulty of problems can be controlled to create comparative tests with a range of difficulties, and there may be graded-difficulty versions of one test which represent easier or more difficult challenges. These may even be used to define various levels of certification.

A second variety of mastery model definition is more appropriate for courses whose goal is basic, less comprehensive and less complex skills. IT consists of evaluating students for mastery in individual skills, allowing them to certify in isolated areas of job performance one at a time. A mastery model of this sort might evaluate the student on some level of proficiency at performing basic skills such as takeoff, basic intercept or delivery types, or refueling under a given set of conditions.

The principles behind both these forms of mastery model are the same: The criterion which the student must meet is stated. The difference in mastery model types exists in the length and complexity of the skills being evaluated and therefore the realism of performance compared to real job settings and the control the evaluator can exercise over the course of the evaluation problem. For a "problem situation" mastery model, although the beginning conditions of the problem may be stated very clearly, subsequent events during the problem cannot be carefully controlled. In the second variety of mastery model, which will be called the "individual task" model, the behaviors to be performed, the conditions existing during performance, and the standards by which they will be evaluated can be carefully designated.

Even though the mastery model types are described here separately for purposes of clarity, it should be apparent that they are, infact, different points along the same dimension. Mastery models of both kinds must be constructed for F-16 training. The individual task mastery model will be used for earlier phases of training, particularly to determine graduation from RTU and within phases for RTU training. The more comprehensive problem situation mastery model will be used to measure the attainment of later, career-level performance goals. As the F-16 student advances out of one type of mastery model, he will be progressively advancing into the other, higher-level, mastery model. Problem-related mastery models will take the form: (1) a mission to be executed, (2) a set of environmental conditions (weather), (3) a set of threat conditions (some known to the student and some not), (4) relevant mission planning data, and (5) a statement of the expected student behavior, stated in terms of advantage gained, kills, avoidance of kill, or any combination of these, along with a percentage figure stating how often the

student must be successful against known and unknown adversary attacks. Problem situation mastery models are likely to be of major importance to continuation training. Definition of these mastery model problems will take place in project Phase V when the continuation training syllabus is generated.

For RTU training and the training directly following it, the individual task mastery model is to be used to bring the student to the point of readiness for more lengthy problems. The derivation of the task-related mastery model is somewhat more mechanical. First, major areas of the mastery model are defined within which competance will be judged. Then individual task listing tasks are assigned to each emphasis area. Then, for each task the various appropriate levels of performance to be required of students are defined. The final mastery model consists of a statement of the tasks to be evaluated by the mastery model and the level of competance required of students for each task. Each step in individual task mastery model construction is discussed separately below.

5.3.1.1 Step 1A: Define Major Emphasis Areas and Assign Tasks to Each

The main purpose of defining major areas of emphasis is to bring together from various parts of the task listing those tasks which are likely to be trained within one time frame. This process is useful because it begins to divide the entire task listing into smaller, more workable units. It may be, at some future stage of the syllabus building process, that a developer will detect some benefit to be gained from breaking apart an emphasis area and spreading it across the syllabus. Creative division of traditional or most readily apparent emphasis areas should be encouraged in the development of innovative syllabus patterns. In the absence of such innovation, a good starting point is the traditional emphasis area division.

Tasks should be allocated to an emphasis area which (1) requires the same level of sophistication in aircraft operation and (2) requires the same knowledge base to be referenced. Traditional groupings of tasks into emphasis areas may be called "Basic Flight Maneuvers," "Navigation," and "Air-to-Air Combat."

5.3.1.2 Step 1B: Break Emphasis Areas into Sub-areas and Divide Tasks Accordingly

Further breakdown of the emphasis areas into sub-areas facilitates later steps in syllabus building. This is accomplished by identifying within emphasis areas sub-groupings of tasks which (1) require about the same level of performance sophistication, (2) use the same aircraft subsystems, or (3) require the same knowledge base. These breakdowns may go so far as to specify individual areas of qualification for students,

that is, aircraft operation areas within which a student may be certified competent, for example "takeoff," or "day refueling."

5.3.1.3 Step 1C: Assign Performance Criteria to Each Task for Each Level of Competence to be Certified

As the final part of mastery model development, the level of proficiency expected for each emphasis area must be set. These may correspond with CRO standards. Intermediate levels of criteria may be set as well to be used as an intermediate level of certification. Setting these levels of proficiency fixes the sequence of performance levels through which a student must pass while progressing toward mastery model attainment. As soon as the student is capable of performing a given area of task to a given level of proficiency, he may be certified at that level and may begin to challenge the next level. This not only helps in student motivation by giving the student a measure of personal progress and goals attained; it also provides a tool to training administrators that allows certifications to be made in exact terms. Designations such as "mission ready" or "combat ready" may be defined in terms of a given group of tasks performed at a given level of proficiency.

5.3.2 Step 2: Identify Prerequisite Sequences Within Each Emphasis Area

Within each emphasis area it is possible to determine tasks which must be trained before other tasks in the same area. It is also possible to determine which tasks are independent of each other and may be taught in any sequence. This information may be obtained in the task listing, through subject-matter expert consultation, and through judgment only if necessary. The product of this step will be a time phasing chart for each emphasis are a showing the order in which tasks may be trained within the area, that is, those which must be trained before others, and those which may be trained at any time.

One task should be taught before another:

1. If it is a simpler, easier-to-learn version of the same task (e.g., Normal take-off should be trained before maximum gross wight take-off).

2. If the second task includes performance of the first task within it. This should have been determined during the task listing process and shown in the task listing.

3. If there is some reason to believe that practice of the first task will make it easier to learn the second task. There may be many reasons for this: Common controls may be used, the task may contain common or similar steps, or there may be other similarities.

The sequence determined during this step within each area will facilitate later steps by identifying necessary prerequisite relations units which may be dealt with as one group of tasks rather than as several individual tasks. Care should be exercised not to identify prerequisite sequences which are really not sequences.

A chart should be constructed during this step on graph paper as illustrated in Figure 6. The vertical line to the right is a terminal point from which sequencing may begin and build backward. In building sequences, as an aid to eliminate much writing and changing, it is suggested that a table top be used and 3 x 5 cards (one for each task) to construct the chart. When a final arrangement of the cards is obtained, the written version of it as in Figure 6 may be drawn.

5.3.3 Step 3: Combine Area Sequences to Form General Syllabus Sequence

During this step a merging of the sequences obtained from Step 2 takes place. The identification of prerequisite sequences should begin using the procedure used for the within-area sequencing activity. As in that procedure, the aim is to demonstrate: (1) tasks which may be taught independently (that is, for which there is no recommended training sequence) and (2) tasks which must be trained prior to other tasks. Also as in the Step 2 procedure, caution should be exercised against specifying sequences which are not necessary or directly contributory to each other. Doing so may prevent innovative sequences from forming during this step.

This activity should not require a mass reshuffling of the tasks between emphasis areas. There may, however, be tasks which are appropriately regrouped on an individual basis. For the most part, this activity should consist of (1) sequencing the major emphasis areas themselves and then (2) reassigning the individual tasks as required.

5.3.4 Step 4: Determine Syllabus Performance Standards and Simplified Task Versions Where Necessary

During the writing of CROs and in earlier steps of sequencing (specifically during mastery model construction), multiple standard levels of performance may have been specified for tasks. At this time the exact standard to be used as the measurement criterion for each task in the syllabus is chosen. Since multiple criteria levels may have been specified for tasks during mastery model preparation, and since these levels reflect on the career-level standards expressed in the CROs, the specification of syllabus criteria for each task may be accomplished to a general degree first by delineating the levels on the mastery model which students must reach for each group of tasks. All

EMPHASIS AREA: TAKEOFF

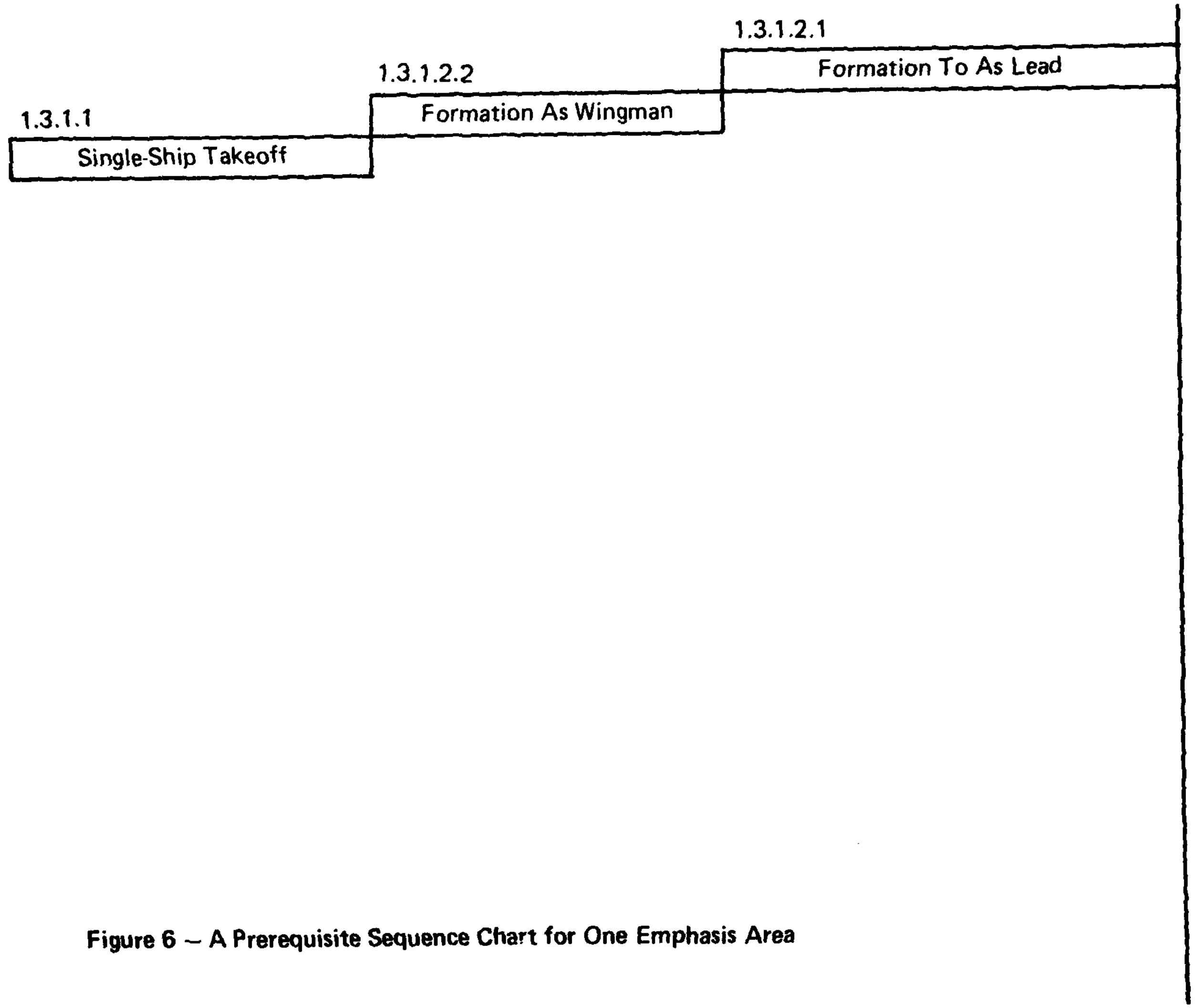


Figure 6 – A Prerequisite Sequence Chart for One Emphasis Area

tasks within the group thus are assigned a criterion level at once in a general statement, and the detailed and exact values for each task may then be added individually.

Also at this time certain tasks may be detected which (1) are too dangerous to be safely performed in the training environment, (2) are too costly to be performed in the training environment, (3) are sophisticated beyond the level of capability a student will have reached during this time in the syllabus, or are difficult tasks which require additional cued and prompted practice under conditions and given aids not found in the task listing version of the task. For too dangerou tasks a form of the task is substituted which is not as dangerous but which satisfies the syllabus developer that the student will have had sufficient experience in performance of a similar task to be able to perform the real task when it is called for in a job environment. For too costly tasks, less costly versions of the same task or less costly similar tasks are substituted. For tasks requiring sophisticated levels of behavior, tasks containing behaviors the student can perform may be substituted, or provisions may be made for instructors to supply the additional needed capabilitiy for students during performance (for example through the use of a dual-seat aircraft). For tasks requiring special guided practice, additional tasks are inserted in the appropriate prerequisite positions which will prepare the students for unguided practice. In some cases, the above problems will have been noted during task analysis, and the task supplied to satisfy the syllabus requirement may have been added and marked with a (T), indicating a "training only" task. *New tasks arrived at* during this step should be added to the task listing with such a mark to distinguish it as a training task rather than a job task.

5.3.5 Step 5: Fill Out Demonstration/Practice/Evaluation Data For Each Task

Steps up to this point have determined the gross structure of the syllabus. During this step data are collected on the amount demonstrated, practice, and evaluation required for the training of each task to syllabus criterion levels in the training device to be used so that the exact dimensions of the syllabus may be determined. This step of sequencing requires exactly the same data to be gathered as Step 30 in the media selection (training device design) procedure. (See project report no. 20, "Media Selection and Utilization Plan Report.") The same data may be used for both media selection and this step of sequencing. Briefly, those data consist of an estimate of the number of repetition in each training device of each task which the rater feels students will require to attain criterion performance levels. Data collected should represent the best collective judgment of instructor-level subject matter experts available. It is important that those subject matter experts have had experience in actually training students in aircrew training tasks, if not in the same aircraft, then in a comparable aircraft. During

the syllabus revision process provision will be made for adjusting these intial estimates in the light of actual data gathered as students use the syllabus. These adjustments will either lengthen the amount of time that students are allowed to practice or reduce it appropriately.

As a quality control during this step it is advised that the widest possible range of subject matter experts have an opportunity to review and comment of the estimates made. If errors are made, they should tend to be generous rather than stingy. As students use the syllabus they will suffer from too few opportunities to practice but not from too many, and unneeded practice can be cut more easily than extra practice can be added.

5.3.6 Step 6: Prepare the Training Device Syllabus Time Line

Up to this point desired syllabus sequences have appeared as linear sequences of tasks. Once training device practice data have been collected in the previous step, the specification of actual syllabus events, aircraft, and simulator flights may take place.

The formal sequence in this structure is the order of aircraft flight, then training device flights in reverse order of complexity. Actual time available for instructional use during each flight is blocked out on a chart. Training events are then selected and placed on the chart, filling a space proportional to the time they will occupy during the flight. This information may be gathered from the data collected in Step 5. That data will also indicate how many sequential flights will require the practice of a given task and will suggest the number of repetitions needed during each. Without violating any of the prerequisite sequences set in earlier steps, all tasks are assigned to flights. This may in many cases become a fitting process, filling spaces of unused flight time with independent and moveable tasks.

The following potential problems should be watched for in building this sequence:

1. Flights should not be filled so full of activities as to prevent the normal flow of discussion and feedback between student and instructor.

2 Adequate re-try time should be available in each flight to provide for unexpected contingencies without disrupting the program of the flight and forcing some activities out.

3. Activities during a flight should alternate where possible between difficult and/or new activities and more simple and/or familiar ones. This will avoid excessive mistakes due to overstress on the students.

5.3.7 Step 7: Insert Academic Instruction for Each Training Device Event

Sequence information contained in the objectives hierarchies is used during this step to insert academic training just prior to the event during which that academic training will be exercised. Objectives which are prerequisite to a given task should be placed in sequence prior to the performance of the task.

In all cases the question should be asked continually whether all prerequisites are being identified, and a regular survey of the entire body of objectives to spot possible omissions is recommended.

The arrangement of academic instruction in the syllabus should show awareness of (1) time and motivation factors and (2) topic similarity relationships. Time and motivation factors should capitalize on the average expected length of the student study time and arrange the amount of instruction in a lesson or unit such that progress measurable to the student may be achieved during each one. Topic similarity relationships should be used to group academic instruction lessons or units. This may produce lessons covering only one type of procedure (e.g., emergencies) or one phase of flight (e.g., takeoff related procedures).

DATE
FILMED

8